Balancing Congestion Relief and Induced VMT

Lead Author:
Ronald T. Milam, AICP, PTP

Contributing Authors:
Jerry Walters, PE
Melanie Gill

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Abstract

Many western U.S. communities continue to expand, creating new demand for public infrastructure including roadways. While few question the need to expand sewer, water, and power infrastructure, expanding roadways stirs debate. Roadway capacity expansion, especially in congested areas, is associated with negative induced vehicle travel effects, including new vehicle miles of travel (VMT). The induced VMT increases energy consumption and emissions, while also diminishing potential congestion relief. While academic research consistently agrees on induced vehicle travel effects, technical guidance for how to apply this research in practice was limited. New guidance has recently been published by agencies such as the California Department of Transportation (Caltrans) and the California Office of Planning and Research (OPR). This paper summarizes the new guidance and explains how to use the academic research to inform practitioner choices about which induced vehicle travel methods are most appropriate in different contexts, while considering their key limitations and strengths.

Introduction

Many western U.S. communities continue to grow, which creates new demand for public infrastructure including roadways. While few question the need to expand sewer, water, and power infrastructure, expanding roadways stirs debate. Roadway capacity expansion, especially in congested areas, is associated with negative effects of induced vehicle travel, including new vehicle miles of travel (VMT). The induced VMT increases energy consumption and emissions, while also diminishing potential congestion relief benefits of new capacity. While academic research has consistently found similar induced vehicle travel effects[1][2][3][4][5], technical guidance for how to apply this research in transportation planning and impact analysis practice is still evolving[6].

Recently, California published new technical guidance on how to analyze induced VMT impacts as part of revisions to the California Environmental Quality Act (CEQA).

- *Technical Advisory on Evaluating Transportation Impacts in CEQA*, California Governor's Office of Planning and Research (OPR) (December 2018), available at: https://opr.ca.gov/docs/20190122-743_Technical_Advisory.pdf
- *Transportation Analysis Framework [TAF] First Edition, Evaluating Transportation Impacts of State Highway System Projects*, Caltrans (September 2020), available at: https://dot.ca.gov/-/media/dot-media/programs/transportation-planning/documents/sb-743/2020-09-10-1st-edition-taf-fnl-a11y.pdf

The revisions to CEQA came in response to Senate Bill (SB) 743, which solidified VMT as the preferred metric for transportation impact analysis. Beyond transportation impacts, VMT is also an important input for air quality, greenhouse gas (GHG), and energy impact analysis under CEQA and may also be required for some projects under the National Environmental Policy Act (NEPA). The new guidance was needed, but also raised questions about specific analytical recommendations. The available methods for analyzing induced vehicle travel have notable limitations. Supporting academic research for elasticity methods raise important questions about the effectiveness of roadway capacity expansion (or other strategies that reduce vehicle travel times) to reduce congestion and VMT. This paper summarizes the new guidance and

[1] See Boarnet and Handy (Sept. 2014) *Impact of Highway Capacity and Induced Travel on Passenger Vehicle Use and Greenhouse Gas Emissions*, California Air Resources Board Policy Brief, p. 2, available at https://www.arb.ca.gov/cc/sb375/policies/hwycapacity/highway_capacity_brief.pdf.

[2] National Center for Sustainable Transportation (Oct. 2015) *Increasing Highway Capacity Unlikely to Relieve Traffic Congestion*, available at http://www.dot.ca.gov/research/researchreports/reports/2015/10-12-2015-NCST_Brief_InducedTravel_CS6_v3.pdf.

[3] Duranton, G., & M. A. Turner (2011). The Fundamental Law of Road Congestion: Evidence from US Cities. American Economic Review, 101(6), 2616-2652. Retrieved from https://www.aeaweb.org/articles?id=10.1257/aer.101.6.2616.

[4] *Road Expansion, Urban Growth, and Induced Travel – A Path Analysis*, Robert Cervero, APA Journal, Spring 2003, Vol. 69, No. 2.

[5] *If you build it, they will drive: Measuring induced demand for vehicle travel in urban areas,* Kent Hymel, Transport Policy, 76, pp 57-66, 2019

[6] Milam, R., Birnbaum, M., Ganson, C., Handy, S., and Walters, J. (2017). Closing the induced vehicle travel gap between research and practice. Transportation Research Record: Journal of the Transportation Research Board, No. 2653, 2017, pp. 10-16.

explains how to use the academic research to inform practitioner choices about which induced vehicle travel methods are most appropriate in different contexts considering their limitations and strengths.

Guidance Summary

As indicated in the OPR's Technical Advisory and Caltrans' TAF, two methods are highlighted to forecast induced VMT: 1) an empirical approach using elasticities derived from academic research, and 2) a travel demand model. Each method has its pros and cons, and practitioners must examine how to reconcile these two methods to perform a complete analysis satisfying the CEQA (and NEPA) expectations.

Elasticity Methods

The elasticity method is based on statistical studies that quantify induced vehicle travel that is exclusively associated with expanding roadway capacity (i.e., adding lane miles). The elasticity of VMT to lane miles includes short-term and long-term estimates of induced vehicle travel effects. Short-term effects occur 1-2 years after a roadway capacity project is open to traffic. Long-term effects tend to occur within a 10 to 20-year timeframe, although the most recent research tends to focus on 20 years. In general, the elasticities reflect the change in total VMT attributable to the project while controlling for other factors that contribute to VMT growth. Some researchers have also included an accounting of the specific sources of induced VMT, including the proportion from passenger versus commercial vehicles. This accounting is relevant for CEQA purposes since different types of VMT may be required depending on the impact subject.

Under the elasticity method, Caltrans recommends the use of National Center for Sustainable Transportation (NCST) Induced Travel Calculator (https://blinktag.com/induced-travel-calculator) to forecast long-term induced VMT. As explained below, the calculator has limitations that practitioners should address. The NCST Calculator includes 2016-2019 VMT and lane-mile data so the user only needs to input the baseline year (preferably the latest year), change in lane miles associated with a proposed project, and the type of functional classification (selected from a drop-down menu). For interstate highways (class 1), the VMT forecast is based on inputs for the corresponding Metropolitan Statistical Area (MSA) and uses an elasticity of 1.0. For other freeways and expressways (class 2) and other principal arterials (class 3), the calculator uses county-level inputs and an elasticity of 0.75.

According to NCST, the calculator is applicable for General Purpose (GP), High Occupancy Vehicle (HOV), or high-occupancy toll (HOT) lane projects involving the addition lanes to class 1, 2, and 3 facilities, which cover the SHS and most major arterials. For a specific map of class 1, 2, and 3 facilities, refer to the Caltrans statewide functional classification map available at the following website - https://dot.ca.gov/programs/research-innovation-system-information/highway-performance-monitoring-system/functional-classification. Users of the map need to zoom in closely to their study area for the map to reveal all functional classes.

The Induced Travel Calculator limitations are listed below. Analysts should consider each limitation and how it may contribute to over- or under-estimates of induced travel effects.

- **The elasticities produce a forecast of total VMT attributable to a project**. This is important since the CEQA Guidelines Section 15064.3(a) states, "For the purposes of this section, "vehicle miles traveled" refers to the amount and distance of automobile travel attributable to a project." One of the main research studies used for the calculator contains the following sources of induced vehicle travel effects.[7]
  - Changes in commercial driving = 19 to 29%
  - Changes in individual or household driving = 9 to 39%
  - Changes in population due to in-migration to the MSA = 5 to 21%
  - Diversion of traffic = 0 to 10%

- **Concentrating on the effects associated only with automobile travel produces lower elasticity values** ranging from 0.14 to 0.70 with changes in individual or household driving being 0.39 to 0.49. The lower elasticity range is aligned with the long-term elasticity of 0.39 that was estimated by Cervero, based on California data. It relies on a modeling methodology that accounted for the effect of previous development and roadway capacity investment on lane mile increases.[8] Other studies have also found an elasticity of lane-miles with respect to total VMT of 0.33 revealing a strong two-way relationship, where every 10% increase in VMT, lane-miles grew by 3.3%.[9] It should also be noted that the Duranton and Turner research revealed a 17% decline in interstate lane-mile per capita compared to a 63% increase in VMT per capita during the 1983-2003 study timeframe.

- **Most of the data used in the research studies ranges from the 1980s to the early 2000s**, although one study extended its data from 1981 to 2015.[10] This period may not be reflective of current VMT trends and may not produce induced vehicle travel elasticities that accurately represent HOT lane effects given their limited availability in comparison to GP and HOV lanes. Also important to note are the substantial socioeconomic changes that were contributing to increasing VMT per capita at the time of data collection (e.g., 1980s to early 2000s). This period was also prior to widespread use of transportation network companies (TNCs), substantial internet shopping, expanded food delivery, and recent COVID-19 travel disruptions.

- **The elasticities are not sensitive to network effects associated with some roadway capacity projects** such as bottlenecks that may have larger effects on travel times, and bridges that can substantially reduce the distance between origins and destinations. Bridges that close a network gap have the greatest potential for reducing VMT due to shorter trip lengths.

- **Without sensitivity to the project corridor context, the calculator results may over- or under-estimate induced VMT effects**. The elasticities are not sensitive to land use context, geographic constraints (e.g., water or topography barriers), or the amount of existing congestion. Bridges are a particularly useful example. A new bridge has the potential to substantially reduce existing trip lengths, which could offset potential induced vehicle travel effects. The elasticity method does not recognize this benefit.

- **The calculator only produces an annual VMT forecast**. Project analysis typically requires weekday forecasts. Simply dividing by 365 days does not produce a reasonable weekday forecast. Use of Performance Measurement System (PeMS) or similar data to estimate an annualization factor is recommended to create weekday values.

- **The VMT forecast represents the project-generated effect but does not include information about the no project condition**. This is one of the bigger limitations of elasticity methods because understanding what would

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[7] *Road Expansion, Urban Growth, and Induced Travel – A Path Analysis*, Robert Cervero, APA Journal, Spring 2003, Vol. 69, No. 2.
[8] Duranton & Turner. *The Fundamental Law of Road Congestion.*
[9] *Induced Travel Demand and Induced Road Investment: A Simultaneous Equation Analysis,* Journal of Transport Economics and Policy, Vol. 36, No. 3, pp 469-490. September 2002.
[10] Hymel, *If you build it, they will drive*.

otherwise happen without the project is required for CEQA/NEPA impact analysis and is essential information for decision making. Travel demand models help isolate what may happen if the project is not built.

- **The VMT forecast does not include a distribution of VMT by speed bin.** VMT by speed bin is commonly needed for air quality and greenhouse gas (GHG) analysis.
- **The VMT forecasts do not include potential VMT effects beyond the MSA or county boundaries**.
- **In uncongested suburban areas, the VMT forecasts from the calculator may be unreasonably high and would not be compatible with observed trip rates and trip lengths**. Without congestion, vehicle trip rates and lengths are not influenced or suppressed in these areas. This lack of sensitivity to corridor land use and congestion context means that adding lane miles in a suburban area with no congestion will have the same proportional effect as adding lane miles in an urban area with multiple hours of congestion. As additional evidence, residential vehicle trip rates in suburban areas have been stable over time across multiple versions of the *Trip Generation Manual* published by the Institute of Transportation Engineers (ITE).

A final note about the use of elasticities derived from research is to recognize the difficulty of 'controlling for' the wide variety of factors that contribute to traffic growth over time. First, travel speed or travel time is the more relevant variable for predicting travel behavior changes. Lane-miles serve as a proxy and are used in the research because the data is easier to obtain, but that should not be interpreted to mean that lane-miles are the sole or even the most relevant variable. Second, one matched-pairs study revealed no statistically distinguishable difference in traffic volume growth rates between highways with capacity expansion versus those without in San Diego, California.[11] Contrary to other research, this finding would suggest that VMT increases resulting from induced vehicle travel effects are solely attributable to longer trip lengths. Hence, this may be an example of the limitation noted above where the elasticity-method is not sensitive to a unique local context. The combination of evidence above suggests that the treatment of induced vehicle travel in transportation impact analysis consider and acknowledge these limitations (see Appendix A for more information).

Travel Demand Models

When utilizing a travel demand model (possibly with off-model post processing), the requirements for analyzing the full impacts of vehicle travel from a capacity-increasing project include changes in VMT due to changes in:

- Trip length (generally increases VMT);
- Mode shift (generally shifts from other modes toward automobile use, increasing VMT);
- Route choice (can act to increase or decrease VMT but is likely to decrease emissions because more direct or preferred facility routing occurs); and
- Newly generated trips (generally increases VMT).

The major issue for practitioners using the travel demand model approach in impact analysis is that most models in California and the rest of the U.S. do not have feedback processes that influence trip generation rates or land use growth allocation. Hence, these components of the models tend to be 'fixed' versus being dynamically linked to changes in accessibility associated with a transportation network modification. Models also tend to lack dynamic validation (i.e., sensitivity testing) to help users understand

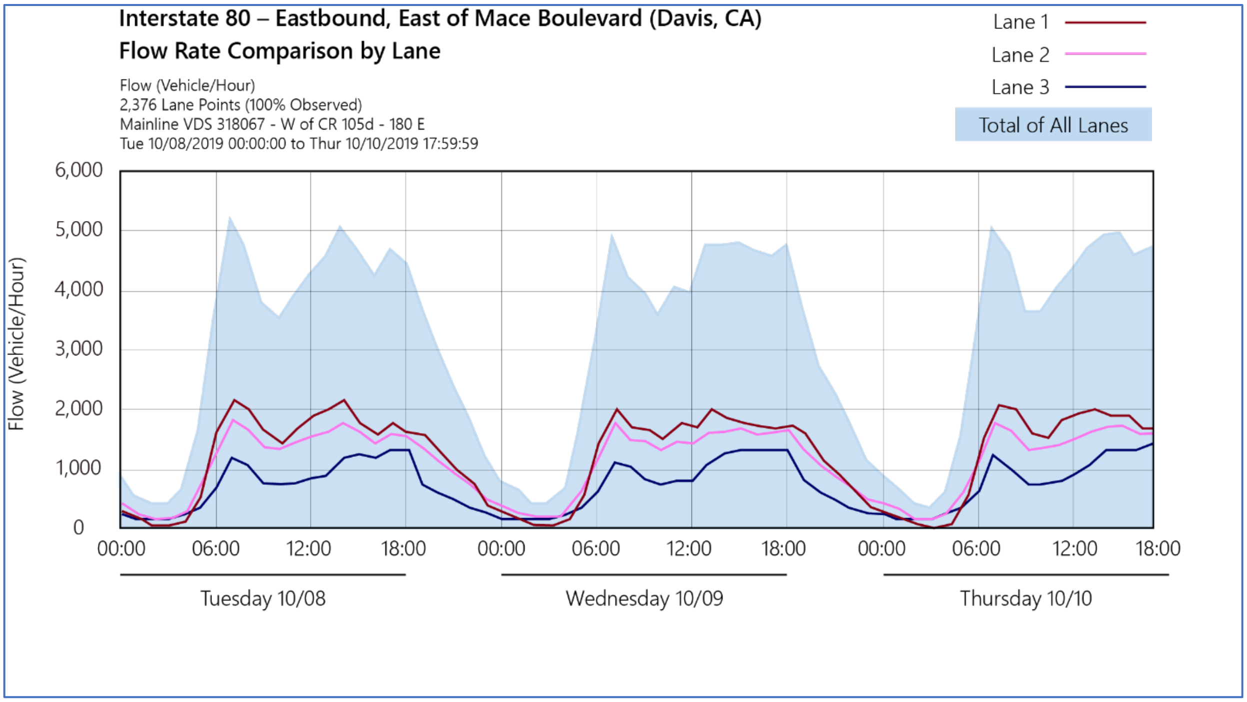
[11] *Revisiting the notion of induced traffic through a matched-pairs study*, Patricia Mokhtarian, Francisco J. Samaniego, Robert H. Shumway, and Neil H. Willits, Transportation 29:193-220, 2002

their level of sensitivity to small network changes. Additional processing is required to handle these limitations of a model, as outlined below.

- **Lack of sensitivity to trip generation; this must be manually adjusted.** If a trip generation module is not sensitive to travel time and cost, the analyst can manually adjust the vehicle trip generation rates or use off-model processing to increase the VMT forecasts. An important part of the adjustment process is to verify that it is warranted. Adjustments may not be appropriate in suburban or rural areas where congestion is not severe enough to suppress existing vehicle trip making. In these settings, land uses are already generating vehicle trips at full demand levels (i.e., rates like those in the ITE Trip Generation Manual) and further increases would not be reasonable due to a roadway capacity change. A comparison to ITE rates could be used as the evidence to determine an appropriate adjustment.
- **Reliance on fixed land use inputs.** Analysts can create alternative specific land use forecasts using expert panels or integrated land use and transportation models as summarized below.
  - Anticipated scenarios must be created, requiring local knowledge. Employ an expert panel, including local agencies' land use planners, to develop a scenario of anticipated land use growth for project alternatives. This process should recognize whether land use effects are intra- or inter-regional. If population is being attracted from an adjacent region, the difference in VMT per capita generation rates may also need to be addressed.
  - Supplemental model runs may be needed. Employ a land use model and run it iteratively with a travel demand model. A wide range of land use models exist, but most are likely to be too time consuming or costly to apply for an individual project.
- **Model results must be adjusted align with the short-term elasticity research**. Note that this is only possible for short-term elasticities, which range from 0.1-0.60 as documented in the CARB research noted above. VMT forecasts from travel models are not directly comparable to long-term elasticity-based VMT forecasts as explained in more detailed below and in Appendix A.
- **Travel demand models may also suffer from limited sensitivity due to their structure or design.** These types of limitations are often revealed through dynamic validation testing and are commonly associated with lack of convergence in trip assignment or lack of feedback processes to trip distribution and mode choice. Regional and local models commonly lack dynamic validation despite industry recommendations to verify the sensitivity of the model's features.[12]
- **Fixed parameters for internal-external (IX) and external-internal (XI) trips, as well as commercial vehicle trips, are a common problem**. These are issues that can be rectified through model refinements and modifications. If these types of sensitivity issues exist with a current model, then projects should rely on the elasticity method for long-term induced VMT forecasts until the model is modified or enhanced to produce forecasts that include all applicable induced travel effects. Verification of the model's sensitivity is a specific requirement of the TAF First Edition. It includes a checklist to evaluate a model's adequacy and sensitivity to long-term induced vehicle travel effects.
- **A final issue that is whether (and how) use of static traffic assignment (STA) instead of dynamic traffic assignment (STA) in travel demand models affects VMT forecasts**. One research paper directly comparing STA and DTA estimates revealed how the limited sensitivity of STA over-predicts traffic volumes, which would

[12] Specific dynamic tests are specified in the *2017 Regional Transportation Plan Guidelines for Metropolitan Planning Organizations,* California Transportation Commission, 2017 and the *Travel Model Validation and Reasonability Checking Manual, Second Edition*, Federal Highway Administration, 2010.

contribute to overestimates of VMT.[13] Further, dynamic tolling for HOT or fully tolled lanes has the potential to increase the vehicle throughput per lane, which could cause induced VMT. Congested freeways tend to have low vehicle throughput per lane during peak periods as shown in the example below. Per lane flow rates drop to as low as 1,100 vehicles per hour during congested hours compared to a functional lane capacity closer to 1,900-2,000 during off-peak hours. Projects that use dynamic tolling can increase the existing flow rates closer to the 1,900 value during peak hours. This difference may include some induced VMT versus VMT that simply shifted from other hours. A DTA would help capture this effect compared to an STA that has limited sensitivity to operational effects throughout individual hours.



Source: Caltrans PeMS, 2022.

Despite the noted model limitations, a model may still be useful to understand the incremental difference between project alternatives that the NCST Calculator or other elasticity methods will not reveal. The model's forecasts of VMT can also be stratified by speed bin, which is important for emissions analysis. Thus, use of a travel demand model may be useful under the following conditions.

- Comparisons between no build and build alternatives in the same analysis year are useful for impact-related decisions. This comparison can be used to estimate a short-term induced vehicle travel elasticity that can be compared against the short-term academic elasticity estimates for reasonableness.
- The NCST Calculator is not applicable or has greater limitations than a travel demand model.
- VMT by speed bin is needed to evaluate emissions for air quality or greenhouse gas analysis.

[13] *Forecasting the impossible: The status quo of estimating traffic flows with static traffic assignment and the future of dynamic traffic assignment,* Research in Transportation Business & Management, Vol. 29, pp 85-92. 2018.

SUGGESTED APPROACHES

Based on the assessments of the two methods, three approaches may apply for CEQA (and NEPA) analysis.

Approach #1: Model Method

The model method, as the name indicates, uses the best available travel demand model to perform the analysis to meet CEQA expectations. The benefit of this method is to generate a complete set of model outputs that can be used to prepare the transportation, air quality, GHG, and energy impact analyses. This method does require the most effort to address model limitations. Before using the model method, the following two steps should be performed to ensure the model is sufficiently sensitive to long-term land use and trip generation changes.

Step 1: Long-term land use change

Reduced congestion along a project corridor could lead to land development occurring farther from urban centers, which could generate more and/or longer trips that increase VMT. Given that most travel demand models do not include a feedback process to land use allocation, an expert panel (such as one comprised of local agencies' planners) could estimate changes to land use growth allocations that would likely result from the project. The resulting allocations could then be input to the travel demand model to analyze effects on vehicle travel. Note that different alternatives associated with the same project, e.g., GP lane alternative vs. HOT lane alternative, may lead to different amounts of land use change.

Step 2: New trip generation

The travel demand model trip rates should be assessed on whether they reflect suppressed travel due to congestion. In other words, is congestion severe enough in the study area that residents, workers, or visitors choose not to make some trips? If suppressed travel is confirmed, then an increase in vehicle trip rates may occur due to the improved traffic condition resulting from the project. An expert panel, which could be the same as the one for the long-term land use change, could be employed to evaluate the potential adjustments needed to trip rates. As noted above, the ITE Trip Generation Manual may serve as a source for 'full demand' vehicle trip rates or household travel surveys based on place or community types without congested conditions.

In addition, the following model parameters should be checked, and if warranted, adjusted to improve sensitivity.

- If the model has fixed IX XI trips, then projects that would be expected to influence IX XI patterns may require post-processing or other adjustments to appropriately account for expected effects.
- Verify that the model's assignment step reaches a stringent convergence criterion such that volume forecasts produced by the model contain limited noise (i.e., unexpected changes in magnitude or distance from the network change).
- Induced commercial vehicle travel effects are often not included in regional and local travel demand models and would require re-estimation or post-processing. In some cases, application of statewide models such as the California Statewide Travel Demand Model may be appropriate to capture commercial vehicle effects. Off-model approaches are another option.

- TNCs and future autonomous vehicles (AV) are not commonly included in travel demand models and may become a larger share of VMT in the future. Creative application of these models, similar to the Fehr & Peers AV testing or post-processing of model outputs, would be necessary to approximate TNC and AV effects.[14] Use of TrendLab+ or other scenario modeling tools including VisionEval may also be appropriate. Guidance from traditional sources such as TRB is still evolving and should be monitored. A recent example is the *Updating Regional Transportation Planning and Modeling Tools to Address Impacts of Connected and Automated Vehicles*, Volume 2: Guidance, Washington DC: The National Academies Press: https://doi.org/10.17226/25332.

As noted above, the TAF First edition includes a checklist (Table 4 of Section 4.5) that specifies model capabilities required for induced vehicle travel assessment, including:

- Land use response to network changes;
- Sensitivity of trip-making behavior to network travel times and travel costs;
- Sufficiency of detail and coverage of modelled roadway and transit networks;
- Network assignment processes – whether the model reaches appropriate convergence; and
- Model calibration and validation.

As recommended by Caltrans, a model should pass all five checks before the analyst concludes that the model is appropriate for producing induced VMT forecasts. Beyond VMT, the model needs to pass these checks to also be acceptable for producing design volumes. In some cases, accepting a model with limitations may still be superior to the elasticity method. The analyst will need to balance the pros and cons of each method given the specific project under analysis and the context. In addition, if the NCST Calculator can be applied to the project, Caltrans recommends that the induced VMT estimated by the model should be within 20 percent of the value provided by the NCST Calculator. ***However, this recommendation does not recognize that current travel demand model forecasts and elasticity-based long-term induced vehicle travel forecasts are not directly comparable.*** Current models do not account for all long-term effects, such as changes in trip generation and land use.

While a model or model process can be developed to include full sensitivity to long-term effects, it will always be challenging to produce a direct comparison to the elasticity-based methods. The elasticity method forecasts VMT changes attributable to a project while controlling for variables such as population growth, employment growth, and income changes because the method is trying to isolate the VMT effect of just adding lane miles.

By contrast, a travel demand model forecasts VMT changes based on variables such as population and employment growth, and income changes, in addition to changes in the transportation network. Extracting the VMT change solely associated with the lane-mile changes over time is not an output that can be directly calculated from a travel demand model. The model results can be used to compare no build and build differences typically caused by changes in trip distribution (activity choice), mode choice, and trip assignment. If feedback to long-term land use growth allocation and vehicle trip generation rates is added to the modeling process, then a travel demand model may produce results closer to the elasticity method but will still suffer the inability to isolate just the long-term VMT change attributable to the increase in lane miles. The expectation of a model appropriately sensitive to short-term and long-term

[14] https://www.fehrandpeers.com/autonomous-vehicle-research/

induced vehicle travel effects is that the long-term change in VMT associated with the project should be greater than the short-term change. Assessments made for models that do not satisfy all the checks above should include disclosure of specific limitations and how they may have affected any associated analysis results.

Use of a model does not exclude use of the elasticity-based method discussed below. The short-term elasticities can be used as a reasonableness check for model no build versus build comparisons. Scenario analysis can also be used to isolate some of the long-term induced vehicle travel effects to verify the reasonableness of model forecasts. For any of these checks, the analyst should clearly identify whether the elasticity method is being used to predict total VMT attributable to the project or select types of VMT such as that associated with induced household driving versus commercial driving.

Approach #2: Elasticity Method

Given the limitation of a travel demand model in estimating long-term induced vehicle travel effects, the empirical-based NCST Induced Travel Calculator, or directly using elasticities, is another way to generate the long-term induced vehicle travel effects on VMT. However, whether to use the full elasticity is an important question given the information presented above about the individual sources of induced VMT that were attributed to lane mile increases.

The online NCST Calculator uses the following standard formula based on published research to estimate VMT attributable to a project (induced VMT):

> *Project-Induced VMT = [%Δ Lane-Miles] x [Baseline VMT] x [Elasticity]*
> where,
> %Δ Lane-Miles = The increase of lane miles expressed as a percentage of the total lane-miles in the study area (i.e., MSA or County as noted above). This must be a positive number.

The benefit of an elasticity-based method is that it requires little effort, however it has the limitations noted in the previous section. Relying on this method alone may not provide a complete picture of potential VMT effects and may over- or under-estimate the impact of induced vehicle travel by not accounting for other factors contributing to long-term traffic increases.

A final consideration for this method is that some induced VMT analysis such as that to comply with CEQA may require isolating the VMT solely from passenger vehicles. This is possible based on an accounting method of induced vehicle travel sources developed by Duranton. Basically, up to .70 of the 1.03 elasticity was due to passenger vehicle related VMT while the remainder was associated with increased commercial vehicle driving.

Approach #3: Hybrid Method

A hybrid method is to integrate both the model and elasticity methods. This approach allows the same land uses for all alternatives but would acknowledge the limitation of using fixed land use inputs. Notably, the discussion would describe which alternative the land use forecasts best reflect and how the accessibility differences between the alternatives could affect the allocation of future growth. The model will be used to forecast the short-term induced travel effect for the build condition of project alternatives, while the NCST calculator is used to forecast long-term VMT effects of the project build alternatives. The details of this method are listed below:

Step 1: The travel demand model will be used to generate volume forecasts and VMT information for no build and build alternatives with a fixed set of land use forecasts.

The agency that developed the land use forecasts will inform the analyst whether these land use forecasts represent the build or no build condition. Typically, project development and environmental impact analysis is only performed on projects that have already been included in a regional transportation plan (RTP), so typical RTP land use forecasts are most likely to represent build conditions.

The environmental document will disclose the limitations of the model with an acknowledgement that the actual land use will likely differ among alternatives. If feasible, the analyst can qualitatively explain how the project could affect land use and what the likely outcome would be in terms of the direction of change with respect vehicle trips and VMT. This could include how the project alternatives could affect the allocation of future growth, whether that reallocation would place additional growth in locations likely to generate higher or lower levels of VMT per capita, and whether the project will increase regional growth totals and VMT or just the regional distribution of the overall growth.

The model will generate short-term (1-2 year) induced vehicle travel effects for each of build alternatives. For base year and opening year with project scenarios, the Home-based Work and Home-based University/School trips should be held constant as in the corresponding no build scenarios, because the work and university/school locations will not change immediately upon the opening of the project to traffic.

Step 2: For the environmental document, the NCST Induced Travel Calculator, or directly the long-term elasticities, will be employed to generate the long-term induced travel effect for VMT.

If multiple alternatives are involved, the NCST Calculator, or directly the long-term elasticities, will be used to generate the long-term induced travel for the build alternatives that include GP, HOV, or HOT lanes. The VMT attributable to the project should be separated into the categories noted above from the Duranton research and disclosed so reviewers understand that some of the induced VMT is directly related to the economic benefits that are likely part of the purpose and need justification for the project.

The model and the NCST induced VMT forecasts can be reported as a range, and the environmental assessment could be based on the VMT forecast that is best suited to the specific corridor context given the documented limitations of each method above. For example, the NCST Calculator may systematically overestimate VMT associated with new bridge lane miles so inclusion of the travel demand model induced VMT effects could help provide a more complete picture of potential effects.

Analysts will need to consider that the induced vehicle effects not captured by the travel demand model could influence the peak hour design volumes used in traffic operations analysis and the VMT by speed bin estimates used for emissions analysis. At a minimum, these limitations should be acknowledged and disclosed in the project development and environmental documents.

Summary of Suggested Approaches

	Model Method	**Elasticity Method**	**Hybrid Method**
Effort Required	High	Low	High
VMT Output	• Total VMT - stratified by speed bin and vehicle type depending on model • Short-term induced VMT	• Long-term induced VMT	• Total VMT - stratified by speed bin and vehicle type depending on model • Short-term induced VMT • Long-term induced VMT
Level of Confidence	**Moderate** – most models will lack full sensitivity to trip generation and land use changes associated with long-term induced vehicle travel effects.	**Moderate** – Limited sensitivity to context and explaining the counter-factual of what would happen if the project is not built.	**Moderate/High** – Same limitations noted for the other two methods but offers the most complete picture of VMT effects.

TAKEAWAYS

The concept of induced vehicle travel is becoming better understood in transportation planning and engineering practice such that public agencies are developing detailed technical guidance. For this guidance to be effective though, it needs to clearly explain the strengths and limitations of applicable methods. This paper complements current guidance and expands on the information available to practitioners to improve the reasonableness and confidence in their forecasting processes and outcomes.